**MODIFIED DREDGE IMPACT MODEL FOR ESTIMATING HOPPER DREDGE ENTRAINMENT IMPACTS TO COLUMBIA RIVER CRAB**

| Field Date | Field Location | Projection | Total Volume Dredged (cy) |
|---|---|---|---|
| 1998-2002 | MCR - Total | 5 Yr Average | 4391872 |

**Sex Ratios by Age Class, Derived from July-Oct Data**

| Age Class | Total | | | Proportion | | |
|---|---|---|---|---|---|---|
| | Male | Female | Sexed | Male | Female | |
| YOY | 2 | 5 | 7 | 0.50 | 0.50 | * binomial distribution p>0.05; low sample size - assumed to be 1:1. |
| 1+ | 24 | 37 | 61 | 0.39 | 0.61 | binomial distribution p=0.026; significantly different from 1:1 |
| 2+ | 25 | 113 | 138 | 0.18 | 0.82 | binomial distribution p<0.001; significantly different from 1:1 |
| 3+ | 5 | 24 | 29 | 0.17 | 0.83 | binomial distribution p<0.001; significantly different from 1:1 |

**Estimates of Crab Entrainment Rate (R), Number of Crabs Entrained (E), Adult Equivalent Loss (AEL), and Variance (AEL)**

| Age Class | R | E | Var(E) | M | S to 2+ | AEL at 2+ | VAR(AEL 2+) | AEL at 3+ | VAR(AEL 3+) |
|---|---|---|---|---|---|---|---|---|---|
| YOY | 0.00335 | 14708.9 | | 0.10 | 0.017 | 24.27 | | 10.92 | |
| 1+ | 0.01440 | 63242.6 | | 0.60 | 0.160 | 6071.29 | | 2732.08 | |
| 2+ | 0.03218 | 141339.9 | | 0.86 | 0.649 | 78887.46 | | 35499.36 | |
| 3+ | 0.01040 | 45661.5 | | 0.86 | 2.222 | 87255.41 | | 39264.93 | |
| All | | 264953.0 | | | | 172238.43 | | 77507.29 | |

Note: Entrained 3+ crab are back-calculated to provide AEL at 2+.

**AGE 2+ Calculations**
**Contribution to Adult Equivalent Loss (AEL at 2+) and Variance (AEL at 2+) by Sex (MALE/FEMALE) and Age Class**

| Age Class | Female | | | Male | | | |
|---|---|---|---|---|---|---|---|
| | Proportion | AEL | VAR(AEL) | Proportion | AEL | VAR(AEL) | |
| YOY | 0.50 | 12.13 | | 0.50 | 12.13 | | R = Crab Entrainment Rate (crabs/cy) |
| 1+ | 0.61 | 3682.59 | | 0.39 | 2388.71 | | E = Crabs Entrained (number of Crabs) |
| 2+ | 0.82 | 64596.25 | | 0.18 | 14291.21 | | M = Post-Entrainment Mortality (proportion) |
| 3+ | 0.83 | 72211.37 | | 0.17 | 15044.04 | | S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% |
| All | | 140502.35 | | | 31736.08 | | AEL = Adult Equivalent Loss |
| | | | | | | | VAR(AEL) =AEL Variance |

**Age Class Distribution**

| Age Class | % of Total | | | Age Class | Proportion of Total AEL | |
|---|---|---|---|---|---|---|
| | of Entrained | of AEL | | | Male | Female |
| YOY | 5.55 | 0.00 | | YOY | 0.0001 | 0.0001 |
| 1+ | 23.87 | 3.52 | | 1+ | 0.0139 | 0.0214 |
| 2+ | 53.35 | 45.80 | | 2+ | 0.0830 | 0.3750 |
| 3+ | 17.23 | 50.66 | | 3+ | 0.0873 | 0.4193 |
| | | | | ALL | 0.18 | 0.82 |

**AGE 3+ Calculations**
**Contribution to Adult Equivalent Loss (AEL at 3+) and Variance (AEL at 3+) by Sex (MALE/FEMALE) and Age Class**

| Age Class | Female | | | Male | | | |
|---|---|---|---|---|---|---|---|
| | Proportion | AEL | VAR(AEL) | Proportion | AEL | VAR(AEL) | |
| YOY | 0.50 | 5.46 | | 0.50 | 5.46 | | R = Crab Entrainment Rate (crabs/cy) |
| 1+ | 0.61 | 1657.16 | | 0.39 | 1074.92 | | E = Crabs Entrained (number of Crabs) |
| 2+ | 0.82 | 29068.31 | | 0.18 | 6431.04 | | M = Post-Entrainment Mortality (proportion) |
| 3+ | 0.83 | 32495.12 | | 0.17 | 6769.82 | | S = Natural Survivorship (proportion); survival to 3+ is assumed to be 45% |
| All | | 63226.06 | | | 14281.24 | | AEL = Adult Equivalent Loss |
| | | | | | | | VAR(AEL) =AEL Variance |

77507.292

**Age Class Distribution**

| Age Class | % of Total | |
|---|---|---|
| | of Entrained | of AEL at 3+ |
| YOY | 5.55 | 0.01 |
| 1+ | 23.87 | 3.52 |
| 2+ | 53.35 | 45.80 |
| 3+ | 17.23 | 50.66 |

| Age Class | Proportion of Total AEL at 3+ | |
|---|---|---|
| | Male | Female |
| YOY | 0.0001 | 0.0001 |
| 1+ | 0.0139 | 0.0214 |
| 2+ | 0.0830 | 0.3750 |
| 3+ | 0.0873 | 0.4193 |
| ALL | 0.18 | 0.82 |

**SUMMARY VARIANCE DATA**

**Entrainment with Confidence Limits**

| E | 264953.0 |
|---|---|
| Var(E) | |
| SE E | |
| Z at 0.975 | 1.95996 |
| 95% C. I. | |
| CV E (%) | |

**TOTAL AEL at 2+ with Confidence Limits**

| AEL at 2+ | 172238.4 |
|---|---|
| Var(AEL2+) | |
| SE AEL | |
| Z at 0.975 | 1.95996 |
| 95% C. I. | |
| CV AEL (%) | |

**TOTAL AEL at 3+ with Confidence Limits**

| AEL at 3+ | 77507.3 |
|---|---|
| Var(AEL3+) | |
| SE AEL | |
| Z at 0.975 | 1.95996 |
| 95% C. I. | |
| CV AEL (%) | |

SE = Standard Error  
Z = Value of Z from Normal Distribution  

C.I. = Confidence Interval  
CV = Coefficient of Variation in %

**MALE AEL at 3+ with Confidence Limits**

| AEL at 3+ | 14281.2 |
|---|---|
| Var(AEL) | |
| SE AEL | |
| Z at 0.975 | 1.95996 |
| 95% C. I. | |
| CV AEL (%) | |

**FEMALE AEL at 3+ with Confidence Limits**

| AEL at 3+ | 63226.1 |
|---|---|
| Var(AEL) | |
| SE AEL | |
| Z at 0.975 | 1.95996 |
| 95% C. I. | |
| CV AEL (%) | |

**TOTAL LOSS TO MALE FISHERY**
(This total would be distributed over 3-4 years)

| Male Age 3+ (number of crab) | Harvest Rate (proportion) | Lost to Fishery (number of crab) | |
|---|---|---|---|
| 14281.2 | 0.70 | 9996.9 | Harvest rate of 0.70 is taken from Armstrong et al. (1987). |

**Loss to Fishery with Confidence Limits**

| Loss to Fishery | 9996.9 |
|---|---|
| Var(AEL) | |
| SE LF | |
| Z at 0.975 | 1.95996 |
| 95% C. I. | |
| CV LF (%) | |

**ADDITIONAL NOTES:**

Mortality Rates (M) for crabs collected in June-September are from Armstrong et al. 1987 (Table 3.3, p. 61)

Survival rates (S) to age 2+ for crab collected from June-September are from Wainwright et al. 1992 (Table 6, p. 178), and

  thereafter survival rate from 2+ to age 3+ is 0.45 (Armstrong et al. 1987).

Sex ratios used were those observed or assumed to be 1:1 where sample size was low.